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Angle Measurement System Based on Ethernet

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Abstract

For the long-distance industrial monitoring and control, angle measuring system based on Ethernet is designed. MEMS accelerometer and the smallest Ethernet chip are used, working principle of system is introduced in detail, and the microcontroller-side software and the PC-side real-time display software based on UDP protocal are presented. The results showed that: the system is highly integrated and reliable, and can be used for a variety of long-distance attitude measurement.

Keywords: MEMS accelerometer; Ethernet; angle measurement system

Instruction

Angle measuring system is widely used in the determination of robot mechanical arm, the tilt measurement of car hull, the judgment of rock mass stretching, and the track testing of engineering drilling. Along with the development of the sensor technology, new MEMS acceleration sensors become small volume, light weight, low consumption, low cost, high reliability and easy to realize digital and intelligent, which are also more and more used in angle measurement field.

In industry measurement and control environment, long distance measurement is unavoidable. RS232, RS485/422 and Ethernet are widely used communication interface. RS232 communication interface are the most commonly used for double direction communication , but its communication distance and transmission speed is limited; RS485/422 are used for difference signal transmission, and has better anti-noise ability and farther the transmission distance in applications which can build connected to a PC distributed equipment network, but the communication distance is still a hard problem;

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Ethernet is a standard open communication network, with low cost, easy to network advantage, high bandwidth, strong sharing resources ability, easy connection, convenient realize office automation network with industrial control network seamless connection, and can realize the enterprise control integration[1].

This paper introduces the design of the acceleration sensor based on MEMS Angle measurement system, chooses internet connection angle measurement system based on the host computer and UDP protocol, and realizes the high precision angle measurement and a host-side port real-time display way.

1. The designation of hardware for angle measure system

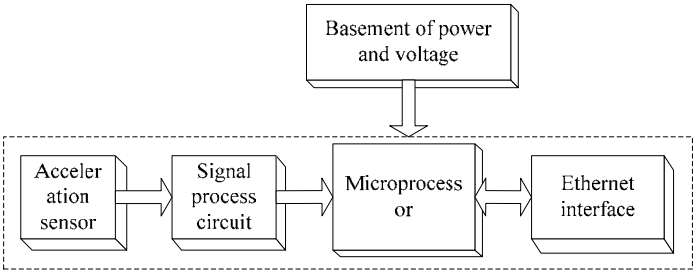

Fig. 1 Block diagram of system

Figure 1 shows the structure of angle measurement system. The system hardware mainly consist of power and voltage benchmark module, MEMS acceleration sensor circuit, signal regulate circuit, microprocessor, Ethernet interface circuit and so on..

1.1 The power and voltage benchmark module

Power supply module uses LM1117 3.3 V chips with input voltage as 4.5 V - 10V to provide the greatest 800mA output current, and it is also low cost[2].

Voltage module uses LT1019, and its benchmark adopts voltage output error less than 0.5%, temperature drift less than 3 ℃ and output voltage benchmarks as 2.5 V.

When the MEMS Angle sensor is in 0 °, the analog output is as its1/2 power source voltage. If the is any fluctuates in the power voltage supply of the angle sensor, its output will produce corresponding fluctuations. So the benchmark power should be tested before it provides power for the MEMS angle sensor. AD benchmark source and MEMS acceleration sensor share the same power supply voltage changes, which can eliminate MEMS Angle sensor caused by power zero drift. Meanwhile the voltage provide offset voltage for signal disposal circuits, after the resistance points pressure and follow amplifier.

1.2 MEMS acceleration sensor circuit

The basic principle of acceleration sensor for angle measuring system is: by measuring the gravity acceleration accelerometer measurement plane component in shaft heft, we can accurately calculated angle value by using trigonometric function. Acceleration sensor adopts the ADXL327 chip produced by ADI company. It has low power consumption, low noise, low cost characteristic, micro machined

capacitive sensing internal contains unit, sensing amplifier and output driver circuit, range for + 2 g. The signal output terminal parallel different capacitance, which can realize the different signal bandwidth and noise, this paper use bandwidth as 500Hz.

1.3 Signal regulate circuit

The bandwidth constraints circuit for sensor circuit has an effect of low pass filtering. Therefore the signal regulate circuit mainly concerns on zero signal adjusting and signal amplification[3]. When use 2.5 V voltage as power supply, the offset voltage value for ADXL327 is 1.25 V, and the output sensitivity as 355 mV/g. In term of gravity measurement, in a shaft and the output voltage range is up 0.895 V - 1.605 V. In order to make full use of digital converter (ADC) measurement range to improve the measurement precision while retaining a certain surplus, the output signal ADXL330 need to recuperate, and amplify circuit is shown in figure 2.

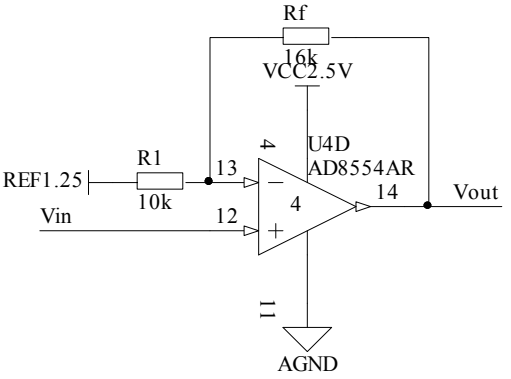

Fig. 2 Circuit of signal conditioning

The processed output voltage is:

$$V_{out} = 2.6V_{in} - 2$$

The output voltage range for processed circuit is 0.327V-2.173V.

1.4 Microprocessor circuit

This part of the circuit include single chip minimize system circuit. System USES C8051F352 microprocessor as the system controller. C8051F352 is on Silicon Labs can truly independent work chip system (SOC). It has 8 KB Flash, which can be used in system programming; Integrated a 8 channels Sigma - Delta l6 bits, the ADC digital-to-analog converters in pieces with calibration function, two independent digital extraction filter can be programmed to 1 kHz sampling rate; With all the way all enhanced SPI interface with UART, eight DAC, and so on. It also supports JTAG chip commissioning, making development debug greatly simplified[4].

This system takes advantage of the piece of C8051F352 ADC acquisition acceleration sensor recuperation signal and utilizes enhanced SPI to connect with Ethernet chip.

1.5 The Ethernet interface circuit

Ethernet chip is adopted as ENC28J60 from Microchip company. It is the least currently encapsulated Ethernet controller, and it is greatly simplifying related design, reducing the occupied space, compatible with the IEEE 802.3 agreement, and integrated MAC and 10base-t physicality and supporting full-duplex and half-duplex mode. It can also do programmable automatic retransmission when data conflicts. It adopt standard serial interface (SPI) to make the interface speed up to 10Mbps; Integrated 8K data receiving send two-port RAM, fast data moving internal DMA controller can configure receive send buffer size, support single-cast and multi-cast and broadcasting; Integrated two programmable LED output, take seven interrupt source two interrupt pin etc, make it become the minimum embedded application Ethernet solutions. Network joint of the isolated transformer with belt network can be HR911105A RJ45 joints. Interface circuit shows as Fig. 3.

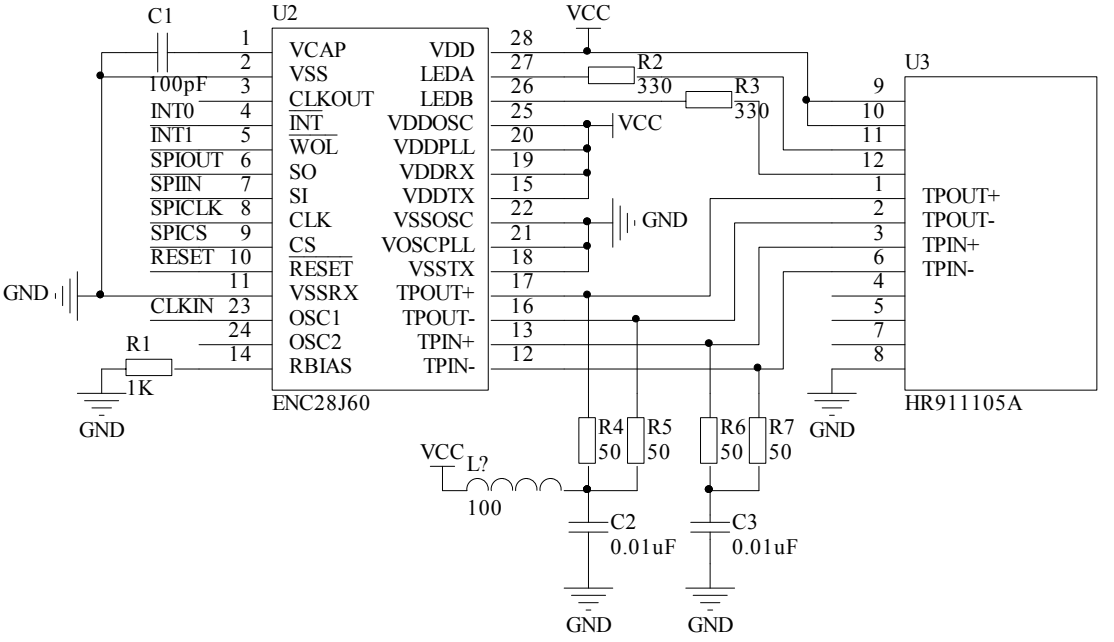

Fig 3 Circuit of communication Interface

2. Software design

System software design is the core part of this design, software is divided into lower place machine (microprocessor) part and PC parts.

2.1 The software of microprocessor

This software is mainly includes signal processing collection, dip angle of decoding, SPI communication and so on. The software program flow chart is shown as shown in figure 4.

In system initialization stage, need to the corresponding register ENC28J60 set and initialization, the initial set work includes sending and receiving buffer, receiving filtering, MAC registers and physical

layer. This system of communication on the pitch of the main data is sent for the connection, which uses the UDP protocol and improves the transmission speed.

2.2 The software of PC

This software is mainly for Ethernet communication, data processing and display. The software interface is shown as figure 5.

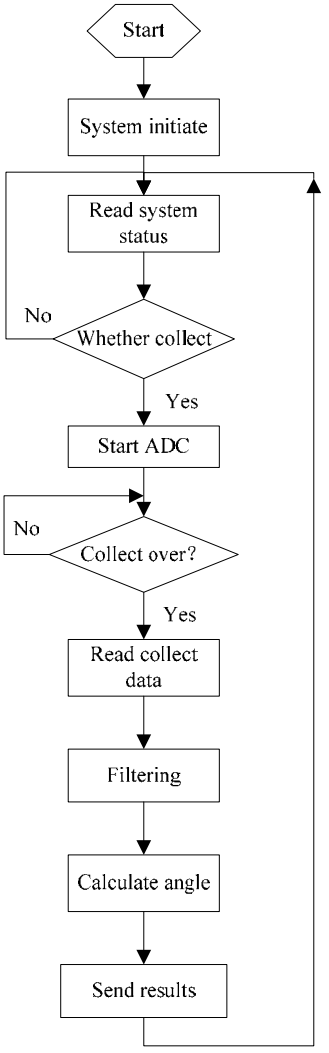

Fig 4 Software flow chart of Microprocessor

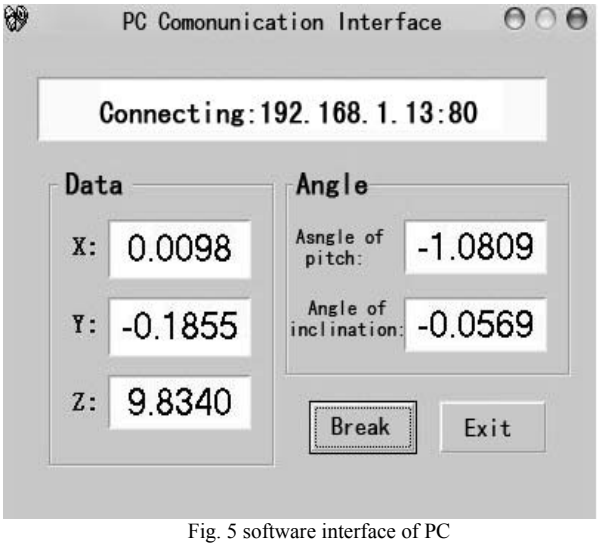

Fig. 5 software interface of PC

3. Results

Fixing test machine to the turntable prototype and making the test turntable turns to different angle position. The system test results are shown in table 1. The system is in 24 hours uninterrupted test, and the data communication comes to be normal which verify the reliability of the system.

Tab. 1 experimental data

NUM	True value /(°)	Output value θ /(°)	Output value r /(°)
1	0	0.20	1.26
2	10	10.56	13.45
3	20	25.65	25.59
4	30	37.04	36.57
5	40	46.72	45.34
6	50	57.45	57.32
7	60	68.76	68.65
8	70	77.29	79.26
9	80	86.08	88.91

From table 1 we can see that the system data has very big measuring error. These errors are caused by sensor manufacturing, installation and circuit parameters which can be inconsistent by error compensation decreases, and improve the system measuring precision

4. Conclusion

For long distance industrial measurement and control environment, the paper designs the angle measurement system based on Ethernet. It makes a detailed introduction of system hardware structure and work principle, designs the micro controller software and PC, and tests the real-time display software. The results validate the system reliability, and it is suitable for long distance posture measurement.

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